LLNL-CONF-672915

LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

Technoeconomic Evaluation of Carbon Capture at Gibson-3

D. A. Jones, T. F. McVey

June 11, 2015

3rd International Symposium on Energy Challenges and Mechanics
Aberdeen, United Kingdom
July 8, 2015 through July 9, 2015

Technoeconomic Evaluation of Carbon Capture at Gibson-3

Presented at the 3rd International Symposium on Energy Challenges and Mechanics

8 July, 2015

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Scope

- Huaneng/Thermal Power Research Institute developed an novel amine absorption process that reduces energy penalty from carbon capture
- LLNL assisted, under CERC, Duke Energy's assessment of this process for running a test on a slipstream from the Gibson-3 generation unit using Illinois-basin coal, post-Flue Gas Desulfurizer
- LLNL developed process and economics models based on a paper on use of MEA by the key developers of the Huaneng process [1] and on a patent issued to Xi'an Thermal Power Research Institute listing several novel amine compositions for CO_2 removal [2]

Overall considerations, Gibson-3 carbon capture

- The carbon capture plant is to remove 90% of the carbon dioxide from a stream containing 25.5% of the flue gas from the Gibson-3 unit
- This amounts to a removal rate of 1,136,000 tonnes per year (MT/y) with an 80% duty factor, or a total of 909,000 MT/y
- The flue gas has the following molar concentrations
  - CO_2 9.6%
  - Water 15.6% (saturated)
  - Nitrogen 68.2%
  - Oxygen 6.6%
  - SO_2 64 ppm

Parameters of carbon capture of 25.5% of Gibson-3

Parameter	
Capture rate	909,000 tonnes per year (MTPY)
Capture efficiency	90%
Flue gas input CO2	1,000,000 MTPY
Duty factor	80%
Instantaneous capture rate	1,136,000 MTPY
Amount of Gibson 3 flue gas processed	25.5%
Gibson 3 total thermal output	1,809 MWth
Gibson 3 total electrical output	696.5 MWe
Gibson 3 net electrical output	635 MWe
Loss due to peripherals	61.5 MWe
Net electrical output of 25.5% of plant	161.9 MWe

Description of the modeled carbon capture process

- The flue gas from the FGD system, saturated in water at 54.4°C, is cooled to 44.4°C and some water is condensed and removed
- The flue gas is then fed to an absorber column where the CO_2 and SO_2 are absorbed by the amine
- The solution, now rich in CO_2, is heated in a regenerative heat exchanger and fed to a stripper column where the CO_2 is removed and sent to a compression plant where water is removed and the CO_2 is compressed to 153 bar
- The lean solution returns through the regenerative heat exchanger to be fed to the absorber, after water and amine are added to replenish the feed solution
- Because the SO_2 remains bound to the amine, a purge stream, not shown, prevents buildup of the amine sulfite salts. The purge stream is fed to an ion exchange column, not shown, to remove the sulfite and return some amine to the system
- According to Duke, steam for the reboiler is available only as low pressure steam at approximately 330°C and 11 bar suggesting the possibility of a low pressure turbine to recapture some of the energy loss.

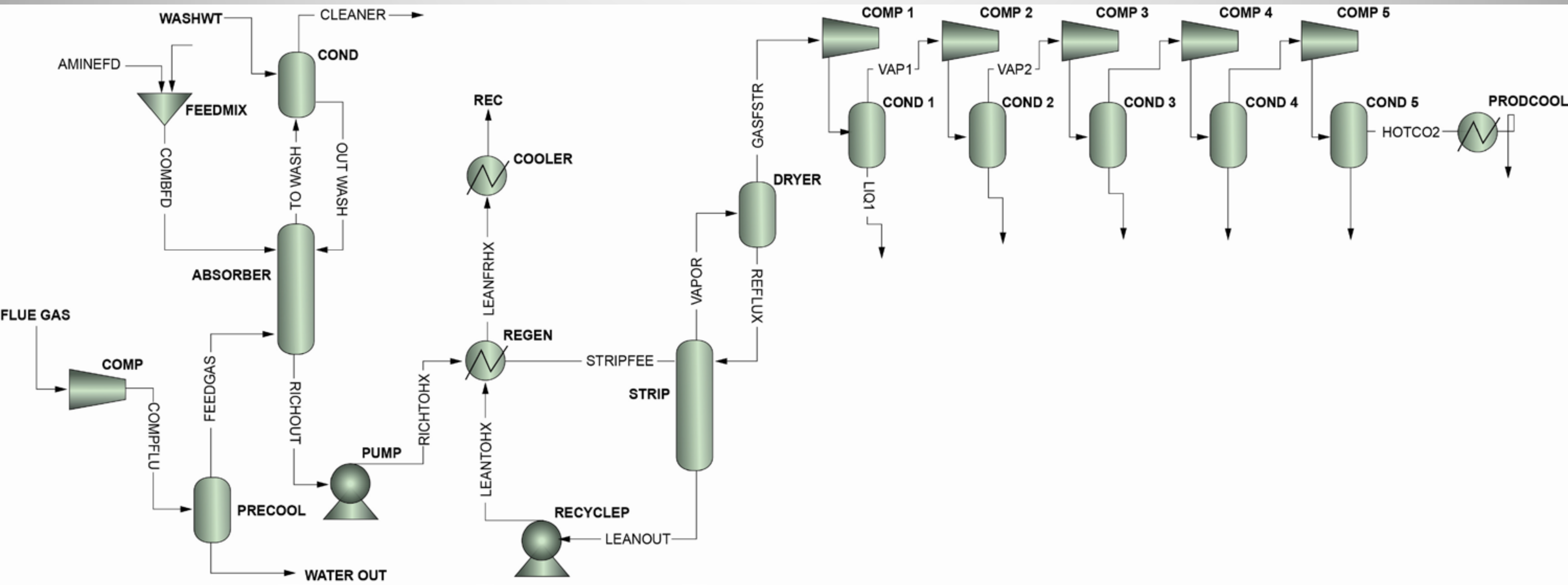
What to Use to Model the Novel Amine Case?

- Modeling of new technology required specification of the amine composition
  - Not only for physiochemical behavior and performance, but also for raw material costs
- Patent CN 101537340A assigned to Xi'an TPRI had many of the individuals listed as inventors who we knew we associated with Huaneng's technology (e.g. Dr. Liu, Dr. Xu) [2]
  - Patent used MEA, hindered amines, and certain accelerants for the process
  - We used compositions from this patent for our design basis
  - However, patent did not contain information on performance of example compositions

What to Use to Model the Novel Amine Case? (cont'd)

- We chose the composition from the patent that deviated the most from an MEA-only solvent
  - 0.5 MEA: 0.4 MDEA (methyl diethanol amine): 0.1 AMP (2-amino-2-methyl-1-propanol)
  - Patent indicated a range of total amine from 10-40%
  - We initially modeled 30%, then raised to 35%
- Confirmed w/Huaneng by email whether this composition was a fair representation of their technology

Figure 1. Process Flow Diagram



Absorption column sizing

- Using a rigorous RADFRAC equilibrium model for this column and a HETP of 4.1 ft, based on work by Freguia, [3] we estimate a column diameter of 12.0-12.5 meters, depending on the amine mix, and a packing height of 18 meters, using the 2.5-Y structured packing recommended by Koch-Glitsch engineers
- Huaneng [4] estimated a column diameter of 12.4 m and a height of 10.2m using RATESEP for 1-Y packing
- Most researchers, including Huaneng, have found that the amine absorber is reaction-rate controlled and will therefore require either RATEFRAC or Aspen's RATESEP add-on for better simulation fidelity

Stripping column sizing

- Using the same procedure for MEA, we calculated the stripping column to be 7.5 m high and 6.8-7.2 meters in diameter, compared to Huaneng's estimation of 7.5 m in height and 6.4 m in diameter

- These values are subject to change upon receipt of information of the actual amine to be used

- Based on information from Kohl and Riesenfeld [5], the stripping column height would be about 6 meters

Table 3. LLNL model results

	LLNL results MEA 30%	LLNL results Mix 30%	LLNL results Mix 35%	Huaneng model MEA 30%
CO_2 recovery	90%	90%	90%	90%
Liquid CO_2 purity	99.5%	99.5%	99.5%	100%
CO_2 production, MT/h	130.9	130.2	130.0	125TPH
CO_2 pressure, bar	153	153	153	50
Electrical load for compression and pumps, Mwe	11.9	11.9	11.8	unknown
Electrical generated by turbine, MWe	9.6	9.2	8.9	0
Reboiler load, MW/GJ/MT	122/3.36	115/3.18	109/3.02	177 MWt*, 4.6 GJ/Ton
Cooling load, MW	127	135	126	unknown
LP extracted kg/h	192,000	181,000	172,000	0
Energy loss /efficiency loss	21.1/7.4%	20.3/7.1%	19.7/6.9%	unknown
Loss without turbine	27.4/9.6%	26.3/9.2%	25.3/8.9%	unknown

* Reboiler load calculated from reported value of 5.1 GJ/MT

Plant cost estimates are location specific

- Process Model and Economics Developed for 0.9 MM MT/y MEA process at 80% availability
- Estimates made location-specific by using:
  - Generation penalty for steam diverted to regenerate amine with data from Duke Energy
  - Estimated the opportunity cost of foregoing generation and cost of parasitic electricity losses from CO_2 compression using 2006-2011 average bilateral contract electricity prices from the Midwest ISO/Cinergy ($51/MWh)
  - Estimated a 20% additional capital cost complexity factor for retrofit compared to greenfield costs
  - Civil engineering-related installation costs for plant equipment were also increased to account for difficult geotechnical conditions where the CO_2 capture plant would likely be constructed (ash, poorly consolidated soils, seismically sensitive area)

Other Economic Assumptions

- Assumed primary construction material to be 304 SS
- Assumed two parallel absorption/desorption process trains to allow turndown to 40% of capacity
- CO_2 -removal plant utilities & offsite investment limited to additional cooling water utility and tankage for amine and other chemicals used
  - Assumed process water and steam supplied by main Gibson plant
  - Although the Gibson Power Plant is located near a lake, the existing large heat loads rejected into the lake prevent its use as a cooling water source for the CO2 capture plant

Energy Penalty Estimates for MEA

- Efficiency penalty from CO_2 capture in our base-case model is:
  - 9% with a letdown turbine to recovery electricity from steam consumed prior to reboiler
  - Reduction in plant efficiency from 35% to 25%
- Use of a Letdown turbine to recover energy from LP cycle steam prior to stripper reboiler reduces the energy penalty of the process
- Use of a Letdown turbine is economical if the cost of electricity is greater than ~$34/MWh

Restrictions and their consequences

- Design to maximum cooling water temperature of 40°C
  - This results in a higher temperature in the absorber, reducing the driving force of CO_2 absorption
  - Huaneng's model called for cooling the flue gas to 40°C before injection into the absorber
  - In our model we fed the flue gas at 44.4°C to the column
- Flue gas from FGD contains 64ppm sulfur dioxide and 100% humidity
  - Because sulfur-containing salts bind strongly with the amine, a purge stream is necessary to prevent buildup of these salts
    - We assumed an ion exchange/activated carbon treatment train for the purge stream
  - Huaneng recommends the SO_2 level in the flue gas be reduced to a maximum of 20ppm

Uncertainties

- Amine degradation
  - Absolute MEA degradation rates based on data in Singh, et al. [6]
  - Relative degradation rates for MEA and MDEA extrapolated from published experiments by Lepaumier et al. for aqueous amines at 140 C and high pressures of O_2 and CO_2 [7,8,9]
- Complexity factor is an estimate based on physical layout of the plant and estimates of the complexity factor from NETL
- We increased the civil engineering costs for equipment installation by a factor of 2.5 to allow for the need to drive piling to 50 feet to bedrock because of the absence of competent soil
  - Complexity factor and the increase in civil engineering cost affect the absolute cost estimate, but should not significantly affect the relative cost position of one solvent versus another

Uncertainties (continued)

- Used an equilibrium model rather than a rate-based model for modeling of absorber and stripper
- Use of an equilibrium model would tend to favor economics for the novel process, and disfavor MEA-only process, as MEA has a more rapid rate of reaction than the hindered amines
    - Addition of piperazine can speed reactions
    - Advantage of novel process may be slightly more narrow than estimates
- HETP correlations from literature had to be used, rather than estimates from the model itself
    - Adds uncertainty to column height estimates and to capital costs
- Assumed an ion exchange/activated carbon treatment train was used to treat a purge stream to control build-up of heat-stable salts and remove amine degradation products
    - Novel amine composition may require more complex treatment
    - Higher degradation rates might require vacuum distillation instead of IX/carbon for solvent purification

Base-case Economics for 90% Carbon Capture Using MEA

For a 0.9 MM MT/year unit with 80% availability (on-stream time) and assuming a 20% complexity factor for retrofit:

- Capital cost: US $134 MM (2011 dollars)
- Battery Limits Investment: $97 MM

Levelized Operating cost: US $60.3 MM p.a.

- Variable costs: US $24.8 MM p.a.
- Operating cost of $60.3/short ton CO_2 removed, or $70.2/MWh

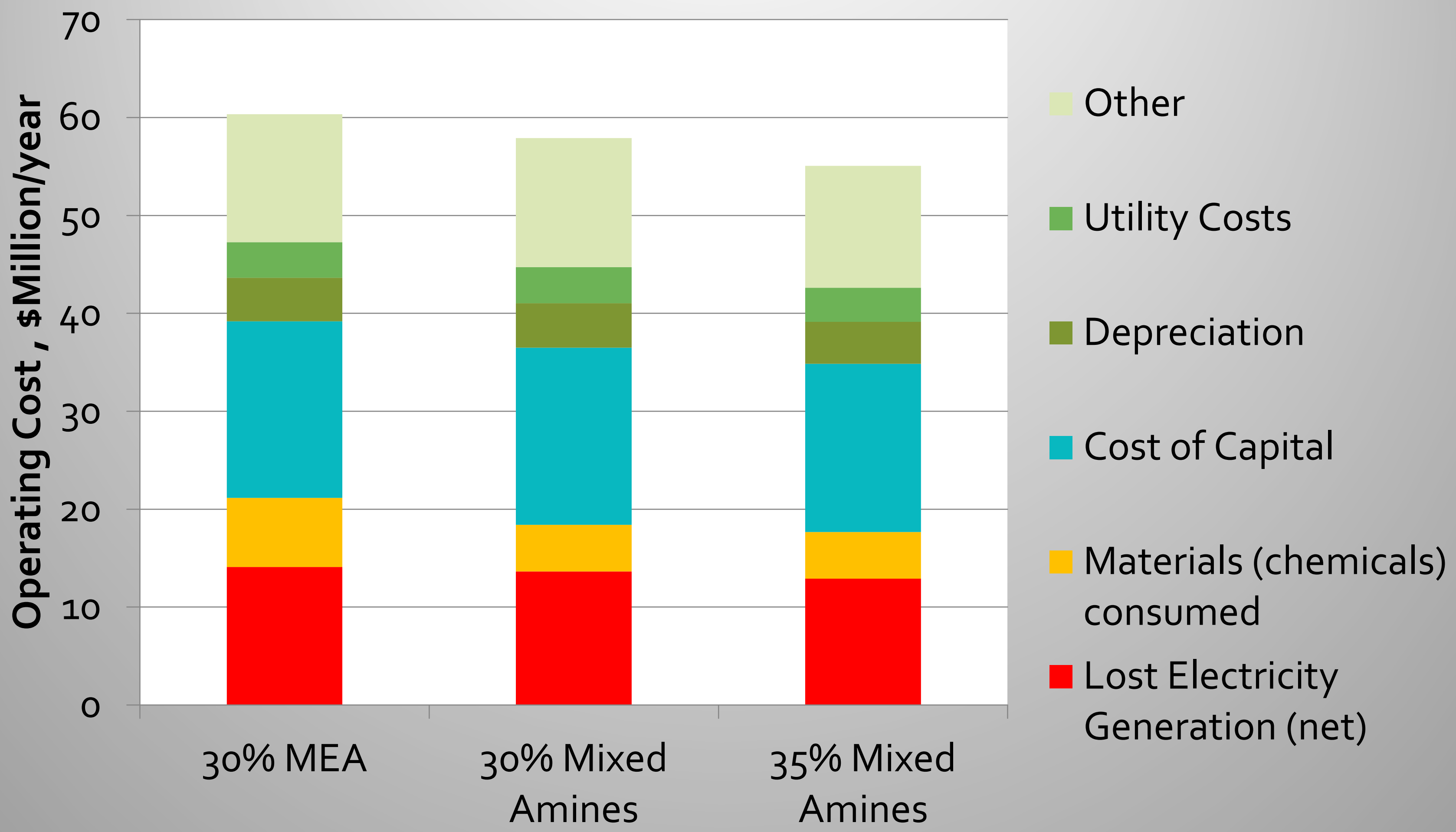
Significant annual operating cost items:

- Loss to generated electricity: $14.1 MM (with letdown turbine)
- Cost of Capital at 12.5% discount rate: $18.0 MM
  - Levelized Depreciation (3.3%): $4.5 MM p.a.
- Amine & Stabilizer Costs: $6.0 MM p.a.: ~10% of estimated op. costs)

Observations for 30% MEA versus 30%/35% Mixed Amines

- Equipment types, sizes, duties are very similar between the base case for 30% MEA and for 30% Mixed amines
  - Unit operations are the same
  - Differences found between processes in terms of equipment sizes are minor
  - Slight advantage in reboiler duty gives a mild but not insignificant improvement in operating costs for 30% Mixed amines
  - Increase in mixed amine concentration to 35% further improves both capital and operating costs
- Literature suggests MDEA, AMP are more thermally stable, and more resistant to oxidative and CO_2-induced degradation than MEA
  - Literature also suggests AMP is less corrosive than MEA
  - Dow is sole U.S. manufacturer in the U.S. of AMP
  - Multiple U.S. manufacturers of MEA and MDEA

Summary of Economics



Modeling Conclusions

- 90% removal of carbon dioxide can be accomplished with an energy loss of 27% using monoethanolamine
- Using an amine mix from Huaneng's patent, and amine concentrations of 30-35% we saw a reduction to 25-26%, without a turbine, and 19-21% with the turbine
- The results presented here are tentative because we do not know the exact composition or properties of the special amine mixture
- Of the amine systems modeled here, the mixture MEA-MDEA-AMP, 50-40-10%, showed the most promising results when modeled at 35% total amine by weight in the circulation loop
- Our models estimated absorber and stripper column dimensions similar to those presented by Huaneng and other researchers (for MEA)

Economic conclusions

- Based on our current understanding of Huaneng's technology from patents:
  - We see modest gains in thermodynamic efficiency (~0.2-0.35 GJ/tonne CO2) using a mixture of amines described in the patent compared to 30% MEA
  - We project an economic advantage of $4-8/MWh for this technology compared to conventional 30% MEA for 90% carbon capture
    - ~$62-76/MWh additional cost to generation for mixed amines
    - versus $70/MWh for 30% MEA
  - Economic advantages increase if amine solvents with >30% by mass of amines can be used effectively

References

[1] Huang Bin, Xu Shisen, Gao Shiwang, Liu Lianbo, et al., "Industrial test and techno-economic analysis of CO2 capture in Huaneng Beijing coal-fired power station, *Applied Energy* 87 (2010) 3347-3354

[2] Xu, S., et. al., Chinese Patent CN10537340, "Flue Gas Carbon Dioxide Absorbent Useful for Decarburization of Flue Gas of Coal-Fired Power Plant, Comprises Monoethanolamine, N-methyl Diethanolamine, and Sterically Hindered Amine or Piperazine," 23 September, 2009

[3] Freguia, Stefano, "Modeling of CO_2 Removal from Flue Gases with Monoethanolamine," M.S. thesis, University of Texas, 2002

[4] Liu Lianbo, "20110909 Aspen Results from CERI.docx"

[5] A. Kohl and F. Riesenfeld, *Gas Purification*, fourth edition, Houston, Gulf Publishing Co., 1985, pp 91-99

[6] D. Singh, E. Croiset, et al., "Technoeconomic Study of CO_2 Capture from an Existing Coal-fired Power Plant," *Energy Conversion & Management*, 2003, 44 3073-3091

[7] Helene Lepaumier, Dominique Picq and Pierre-Louis Carrette, "New Amines for CO2 Capture. I. Mechanisms of Amine Degradation in the Presence of CO2," *Industrial and Engineering Chemistry Research*, October 21, 2009, 48 (20) 9061–9067

[8] Helene Lepaumier, Dominique Picq and Pierre-Louis Carrette, "New Amines for CO2 Capture. I. Mechanisms of Amine Degradation in the Presence of O2," *Industrial and Engineering Chemistry Research*, October 21, 2009, 48 (20) 68–9075

[9] Sandrine Martin, Helene Lepaumier, Dominique Picq, Jean Kittel, Theodorus de Bruin, Abdelaziz Faraj, and Pierre-Louis Carrette, "New Amines for CO2 Capture. IV. Degradation, Corrosion, and Quantitative Structure Property Relationship Model," *Industrial and Engineering Chemistry Research*, April 8, 2012, 51 (18) 6283–6289

Backup slides

Compositions in examples in CN 101537340A [5]

1. 0.5 MEA: 0.4 MDEA: 0.1 AMP
2. 0.85 MEA: 0.1 MDEA: TBE 0.1: 0.02 Na_3VO_4
3. 0.6 MEA: 0.35 MDEA: 0.04 TBEE: 0.01 Na_3VO_4
4. 0.6 MEA: 0.35 MDEA: 0.04 TBEE: 0.01 Na_3VO_4
5. 0.75 MEA: 0.23 MDEA: 0.01 PZ: 0.01 Na_3VO_4
6. 0.8 MEA: 0.13 MDEA: 0.03 TBEE: 0.05% PZ: 0.02 Na_3VO_4
7. 0.64 MEA: 0.30 MDEA: 0.035 AMP: 0.025% PZ: 0.05 Na_3VO_4

MEA – Monoethanolamine; MDEA – Methyl Diethanolamine: AMP – 2-amino-2-methyl-1-propanol; PZ – piperazine; TBE - 2-tert-butylaminoethanol; TBEE - 2-(2-tert-butylaminoethoxy)ethane: 0.05 Na_3VO_4

Calculating energy usage to operate the stripper – Mixed amines, 30%

- To provide 114 MWt for the reboiler, we extracted 399,000 lb per hour (181,000 kg per hour) of low pressure steam at 330 °C and 11.4 bar, feeding it to a letdown turbine to further reduce the pressure to 2.07 bar, while generating 9.6 MWe of electricity to partially offset the compression and pumping load
- The power loss of the plant for this extraction is 30.7 MWe or 19.0%
- The calculated electrical load for the capture equipment is 11.9 MWe, with the turbine recovering 9.6 MWe of this, for a net power loss of 2.3 MWe, or 1.5%, for a total power loss of 20.3%

Extraction flow lb/hr	Total plant MWe	MWe lost	Energy penalty
0	696.5	0	0
350,000	669.4	27.1	16.7%
399,000	**665.7**	**30.7**	**19.0%**
400,000	665.7	30.8	19.0%
500,000	658.4	38.1	23.5%

Calculating energy usage to operate the stripper – Mixed amines, 35%

- To provide 109 MWt for the reboiler, we extracted 378,000 lb per hour (172,000 kg per hour) of low pressure steam at 331 °C and 11.5 bar, feeding it to a letdown turbine to further reduce the pressure to 2.07 bar, while generating 9.2 MWe of electricity to partially offset the compression and pumping load
- The power loss of the plant for this extraction is 29.2 MWe or 18.0%
- The calculated electrical load for the capture equipment is 11.8 MWe, with the turbine recovering 9.2 MWe of this, for a net power loss of 2.6 MWe, or 1.6%, for a total power loss of 19.7%

Extraction flow lb/hr	Total plant MWe	MWe lost	Energy penalty
0	696.5	0	0
350,000	669.4	27.1	16.7%
378,000	**666.0**	**29.2**	**18.0%**
400,000	665.7	30.8	19.0%
500,000	658.4	38.1	23.5%

 27

Comparison to Previous Studies

- Singh et al.[1] in 2002 estimated the cost of an amine CO_2 retrofit for a 400 MW coal plant to be US $294 MM ($426 MM in 2011 dollars)
- Using a scaling exponent of 0.8, our estimate for the capital cost for a 400 MW retrofit is $276 MM
- Why are our capital estimates lower? Reasons:
    - Singh had capital investment for a supplementary natural gas turbine to compensate for lost generation capacity
    - Singh included costs for a Flue Gas Desulfurizer
    - Singh somewhat overestimated the capital cost for CO_2 drying
- Adjusting Singh's capital cost estimates to account for these differences in scope gives an closer agreement of estimates

Economics for Capture Using 30% Mixed Amine Composition

- For a 1 MM ton/year unit with 80% availability (on-stream time) and assuming a 20% complexity factor for retrofit:
  - Capital cost: US $136 MM (2011 dollars)
  - Battery Limits Investment: $99 MM
- Levelized Operating cost: US $58 MM p.a.
  - Variable costs: US $22 MM p.a.
  - Operating cost of $57.5/short ton CO_2 removed, or $66.6/MWh
- Significant annual operating cost items:
  - Loss to generated electricity: $13.6 MM (with letdown turbine)
  - Cost of Capital at 12.5% discount rate: $18.1 MM
    - Levelized Depreciation (3.3%): $4.5 MM p.a.
  - Amine & Stabilizer Costs: $4.8 MM p.a.: ~8% of estimated op. costs)

Economics for Capture Using 35% Mixed Amine Composition

- Raised mixed amine concentration to 35% because of belief in increased amine stability
- Economics as follows
  - Capital cost: US $129 MM (2011 dollars)
  - Battery Limits Investment: $94 MM
- Levelized Operating cost: US $56.5 MM p.a.
  - Variable costs: US $21.2 MM p.a.
  - Operating cost of $54.7/short ton CO_2 removed, or $62.3/MWh
- Significant annual operating cost items:
  - Loss to generated electricity: $12.9 MM (with letdown turbine)
  - Cost of Capital at 12.5% discount rate: $17.2 MM
    - Levelized Depreciation (3.3%): $4.3 MM p.a.
  - Amine & Stabilizer Costs: $4.8 MM p.a.: ~9% of estimated op. costs)

Need for a Letdown Turbine

- Port on LP Steam Turbine limited to 200,000 lb/hr
  - Not sufficient to meet reboiler steam needs
- Steam before LP cycle is ~150 psig
- However, we need low reboiler temperatures
  - 130°C or lower (equivalent to 30 psig saturated)
  - Higher reboiler temperatures increase amine degradation
  - Could we extract power from the LP steam before sending to reboiler?
- We sized and costed Let-down Turbine to expand 150 psig steam to 30 psig
  - Reduces energy penalty from 27% to 22%

Table 1. Partial Stream Table – 30% MEA

	AMINEFD	CLEANER	CO2LIQ	COMBFD	COMP1ST	COMP2	COMP3	COMP4	COMP5	COMPFLU	FEEDGAS	FLUEGAS	GASFSTR	HOTCO2	LEANFRHX	LEANOUT
Temperature K	317.6	337.2	317.6	317.6	396.8	392.9	394.3	398.1	401.3	328.2	317.6	327.6	320.9	317.6	330.2	384.8
Pressure N/sqm	101281	101352.93	1.53E+07	101574.09	382659	961818.6	2417991	6081865	1.53E+07	103681	103681	101101	1.52E+05	1.53E+07	170272.6	151987.5
Vapor Frac	0	1	1	0	1	1	1	1	1	0.997	1	0.996	1	1	0	0
Mole Flow kmol/sec	1	9.415	0.827	38.54	0.89	0.846	0.833	0.828	0.827	9.489	8.805	9.489	0.89	0.827	38.031	38.034
Mass Flow kg/sec	18.015	245.064	36.318	942.777	37.459	36.66	36.432	36.344	36.318	268.03	255.708	268.03	37.459	36.318	933.977	933.977
Volume Flow cum/sec	0.018	260.039	0.054	0.983	7.604	2.81	1.07	0.393	0.129	248.724	223.987	254.282	15.52	0.054	0.982	1.024
Enthalpy MMBtu/hr	-970.899	-1917.966	-1131.35	-39357.92	-1150.24	-1114.99	-1105.49	-1103.55	-1108.74	-2421.59	-1865.07	-2423.81	-1159.17	-1131.34	-38744.3	-38153.3
Mass Flow kg/sec																
CO2	0	3.398	36.266	0	36.273	36.27	36.268	36.267	36.266	40.038	40.037	40.038	36.273	36.266	0.001	0.147
H2O	18.015	40.402	0.049	613.564	1.183	0.386	0.161	0.074	0.049	26.725	14.404	26.725	1.183	0.049	604.354	603.583
N2	0	181.223	0.003	0	0.003	0.003	0.003	0.003	0.003	181.226	181.226	181.226	0.003	0.003	0	0
O2	0	20.041	0.001	0	0.001	0.001	0.001	0.001	0.001	20.041	20.041	20.041	0.001	0.001	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0	0	0	0.731	0	0	0	0	0	0	0	0	0	0	1.073	4.052
CL-	0	0	0	0.956	0	0	0	0	0	0	0	0	0	0	0.956	0.956
CO3--	0	0	0	0.68	0	0	0	0	0	0	0	0	0	0	0.494	0.133
MEA	0	0	0	111.175	0	0	0	0	0	0	0	0	0	0	110.505	113.893
MEA+	0	0	0	82.98	0	0	0	0	0	0	0	0	0	0	83.302	82.721
MEACOO-	0	0	0	132.692	0	0	0	0	0	0	0	0	0	0	133.292	128.493
Mole Flow kmol/sec																
CO2	0	0.077	0.824	0	0.824	0.824	0.824	0.824	0.824	0.91	0.91	0.91	0.824	0.824	0	0.003
H2O	1	2.243	0.003	34.058	0.066	0.021	0.009	0.004	0.003	1.483	0.8	1.483	0.066	0.003	33.547	33.504
N2	0	6.469	0	0	0	0	0	0	0	6.469	6.469	6.469	0	0	0	0
O2	0	0.626	0	0	0	0	0	0	0	0.626	0.626	0.626	0	0	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0	0	0	0.012	0	0	0	0	0	0	0	0	0	0	0.018	0.066
CL-	0	0	0	0.027	0	0	0	0	0	0	0	0	0	0	0.027	0.027
CO3--	0	0	0	0.011	0	0	0	0	0	0	0	0	0	0	0.008	0.002
MEA	0	0	0	1.82	0	0	0	0	0	0	0	0	0	0	1.809	1.865
MEA+	0	0	0	1.336	0	0	0	0	0	0	0	0	0	0	1.342	1.332
MEACOO-	0	0	0	1.275	0	0	0	0	0	0	0	0	0	0	1.281	1.234

Table 2. Remainder of Stream Table-30% MEA

	LEANOUT	LEANTOHX	LIQ1	LIQ2	LIQ3	LIQ4	LIQ5	OUTWASH	REC	REC2	REFLUX	RICHOUT	RICHTOHX	STRIPFEE	TOWASH	VAP1	VAP2	VAP3	VAP4	VAPOR	WASHWT	WATEROU
Temperature K	383.4	383.4	317.6	317.6	317.6	317.6		322.8	317.6	317.6	320.9	323.2	323.2	372.4	323.1	317.6	317.6	317.6	317.6	371	313.1	317.6
Pressure N/sqm	151987.5	170272.57	382659.03	961818.6	2417991	6.08E+06	1.53E+07	1.01E+05	1047917	1.01E+05	151987.5	101574.1	441777	166173	101574.1	382659	961818.6	2417991	6082555	151987.5	101101	103681
Vapor Frac	0	0	0	0	0	0		0	0	0	0	0	0	0.012	1	1	1	1	1	1	0	0
Mole Flow kmol/sec	44.733	44.733	0.044	0.013	0.005	0.001	0	1.015	44.731	42.986	0.949	44.798	44.798	45.07	8.188	0.844	0.831	0.826	0.825	1.838	1	0.684
Mass Flow kg/sec	1099.855	1099.855	0.799	0.227	0.088	0.026	0	18.289	1099.855	1068.47	17.153	1137.237	1137.237	1137.237	223.246	36.576	36.349	36.262	36.235	54.529	18.015	12.322
Volume Flow cum/sec	1.164	1.164	0.001	0	0	0	0	0.019	1.118	1.087	0.017	1.138	1.138	11.555	216.366	5.728	2.189	0.807	0.248	37.02	0.018	0.012
Enthalpy MMBtu/hr	-4.50E+04	-4.50E+04	-42.996	-12.2	-4.69	-1.402		-984.284	-4.59E+04	-4.42E+04	-921.804	-4.71E+04	-4.71E+04	-4.64E+04	-927.406	-1120.66	-1110.84	-1108.3	-1111.93	-1927.61	-972.04	-664.015
Mass Flow kg/sec																						
CO2	0.114	0.114	0.003	0.002	0.002	0.001	0	0	0	0	0.021	0.046	0.046	12.027	3.899	36.186	36.184	36.182	36.181	36.225	0	0.001
H2O	732.395	732.395	0.796	0.225	0.086	0.025	0	18.289	733.137	701.726	17.083	728.079	728.079	731.151	18.085	0.386	0.16	0.074	0.049	18.271	18.015	12.32
N2	0	0	0	0	0	0	0	0	0	0	0	0.004	0.004	0.004	181.221	0.004	0.004	0.004	0.004	0.004	0	0
O2	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0.001	20.04	0.001	0.001	0.001	0.001	0.001	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	4.314	4.314	0	0	0	0	0	0	1.366	1.312	0.021	21.764	21.766	12.385	0	0	0	0	0	0	0	0
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0.116	0.116	0	0	0	0	0	0	0.544	0.511	0	1.288	1.285	0.279	0	0	0	0	0	0	0	0
MEA	48.32	48.321	0	0	0	0	0	0	38.803	38.787	0	3.089	3.093	14.234	0	0	0	0	0	0.015	0	0
MEA+	45.729	45.727	0	0	0	0	0	0	52.686	52.542	0.015	59.523	59.519	54.51	0	0	0	0	0	0	0	0
MEACOO-	110.382	110.382	0	0	0	0	0	0	114.936	115.204	0	164.331	164.331	153.743	0	0	0	0	0	0	0	0
MDEA	96.792	96.79	0	0	0	0	0	0	112.967	112.781	0	44.262	44.257	61.77	0	0	0	0	0	0.01	0	0
AMP	18.288	18.288	0	0	0	0	0	0	15.312	15.189	0	2.211	2.213	7.683	0	0	0	0	0	0.003	0	0
AMP+	13.479	13.48	0	0	0	0	0	0	16.49	16.613	0.003	29.739	29.736	24.204	0	0	0	0	0	0	0	0
MDEA+	29.927	29.929	0	0	0	0	0	0	13.615	13.803	0.01	82.901	82.906	65.245	0	0	0	0	0	0	0	0
Mole Flow kmol/sec																						
CO2	0.003	0.003	0	0	0	0	0	0	0	0	0	0.001	0.001	0.273	0.089	0.822	0.822	0.822	0.822	0.823	0	0
H2O	40.654	40.654	0.044	0.013	0.005	0.001	0	1.015	40.695	38.952	0.948	40.415	40.415	40.585	1.004	0.021	0.009	0.004	0.003	1.014	1	0.684
N2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.469	0	0	0	0	0	0	0
O2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.626	0	0	0	0	0	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0.071	0.071	0	0	0	0	0	0	0.022	0.022	0	0.357	0.357	0.203	0	0	0	0	0	0	0	0
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0.002	0.002	0	0	0	0	0	0	0.009	0.009	0	0.021	0.021	0.005	0	0	0	0	0	0	0	0
MEA	0.791	0.791	0	0	0	0	0	0	0.635	0.635	0	0.051	0.051	0.233	0	0	0	0	0	0	0	0
MEA+	0.736	0.736	0	0	0	0	0	0	0.849	0.846	0	0.959	0.959	0.878	0	0	0	0	0	0	0	0
MEACOO-	1.06	1.06	0	0	0	0	0	0	1.104	1.107	0	1.579	1.579	1.477	0	0	0	0	0	0	0	0
MDEA	0.812	0.812	0	0	0	0	0	0	0.948	0.946	0	0.371	0.371	0.518	0	0	0	0	0	0	0	0
AMP	0.205	0.205	0	0	0	0	0	0	0.172	0.17	0	0.025	0.025	0.086	0	0	0	0	0	0	0	0
AMP+	0.15	0.15	0	0	0	0	0	0	0.183	0.184	0	0.33	0.33	0.269	0	0	0	0	0	0	0	0
MDEA+	0.249	0.249	0	0	0	0	0	0	0.113	0.115	0	0.69	0.69	0.543	0	0	0	0	0	0	0	0

Table 2. Partial Stream Table – 30% Amine Mix

	AMINEFD	CLEANER	CO2LIQ	COMBFD	COMP1ST	COMP2	COMP3	COMP4	COMP5	COMPFLU	FEEDGAS	FLUEGAS	GASFSTR	HOTCO2	LEANFRHX
Temperature K	317.6	322.8	317.6	317.6	396.8	392.9	394.3	398.1	401.3	328.2	317.6	327.6	320.9	317.6	327.7
Pressure N/sqm	101281	101352.93	1.53E+07	101574.09	382659.03	961818.6	2417991	6081865	1.53E+07	103681	103681	101101	151988	1.53E+07	1.70E+05
Vapor Frac	0	1	1	0	1	1	1	1	1	0.997	1	0.996	1	1	0
Mole Flow kmol/sec	1	8.173	0.825	43.986	0.888	0.844	0.831	0.826	0.825	9.489	8.805	9.489	0.888	0.825	44.731
Mass Flow kg/sec	18.015	222.972	36.235	1086.485	37.375	36.576	36.349	36.262	36.235	268.03	255.708	268.03	37.375	36.235	1099.855
Volume Flow cum/sec	0.018	216.227	0.054	1.105	7.588	2.804	1.068	0.392	0.128	248.724	223.987	254.282	15.487	0.054	1.123
Enthalpy MMBtu/hr	-970.899	-915.162	-1128.71	-4.51E+04	-1147.64	-1112.39	-1102.91	-1100.97	-1106.15	-2421.594	-1865.07	-2423.81	-1156.55	-1128.69	-4.57E+04
Mass Flow kg/sec															
CO2	0	3.899	36.181	0	36.188	36.186	36.184	36.182	36.181	40.038	40.037	40.038	36.188	36.181	0.001
H2O	18.015	17.811	0.049	719.726	1.182	0.386	0.16	0.074	0.049	26.725	14.404	26.725	1.182	0.049	733.072
N2	0	181.221	0.004	0	0.004	0.004	0.004	0.004	0.004	181.226	181.226	181.226	0.004	0.004	0
O2	0	20.04	0.001	0	0.001	0.001	0.001	0.001	0.001	20.041	20.041	20.041	0.001	0.001	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0	0	0	1.346	0	0	0	0	0	0	0	0	0	0	1.699
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0	0	0	0.531	0	0	0	0	0	0	0	0	0	0	0.433
MEA	0	0	0	38.74	0	0	0	0	0	0	0	0	0	0	40.197
MEA+	0	0	0	52.644	0	0	0	0	0	0	0	0	0	0	51.494
MEACOO-	0	0	0	115.114	0	0	0	0	0	0	0	0	0	0	114.558
MDEA	0	0	0	112.864	0	0	0	0	0	0	0	0	0	0	110.403
AMP	0	0	0	15.245	0	0	0	0	0	0	0	0	0	0	15.685
AMP+	0	0	0	16.557	0	0	0	0	0	0	0	0	0	0	16.112
MDEA+	0	0	0	13.719	0	0	0	0	0	0	0	0	0	0	16.201
Mole Flow kmol/sec															
CO2	0	0.089	0.822	0	0.822	0.822	0.822	0.822	0.822	0.91	0.91	0.91	0.822	0.822	0
H2O	1	0.989	0.003	39.951	0.066	0.021	0.009	0.004	0.003	1.483	0.8	1.483	0.066	0.003	40.692
N2	0	6.469	0	0	0	0	0	0	0	6.469	6.469	6.469	0	0	0
O2	0	0.626	0	0	0	0	0	0	0	0.626	0.626	0.626	0	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0	0	0	0.022	0	0	0	0	0	0	0	0	0	0	0.028
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0	0	0	0.009	0	0	0	0	0	0	0	0	0	0	0.007
MEA	0	0	0	0.634	0	0	0	0	0	0	0	0	0	0	0.658
MEA+	0.00%	0	0	0.848	0	0	0	0	0.00%	0	0	0	0	0	0.829
MEACOO-	0	0	0	1.106	0	0	0	0	0	0	0	0	0	0	1.101
MDEA	0	0	0	0.947	0	0	0	0	0	0	0	0	0	0	0.926
AMP	0.00	0	0	0.171	0	0	0	0	0	0	0	0	0	0	0.176
AMP+	0.00	0	0	0.184	0	0	0	0	0	0	0	0	0	0	0.179
MDEA+	0.00	0	0	0.114	0	0	0	0	0	0	0	0	0	0	0.135

Table 2. Remainder of Stream Table-30% Amine Mix

	LEANOUT	LEANTOHX	LIQ1	LIQ2	LIQ3	LIQ4	LIQ5	OUTWASH	REC	REC2	REFLUX	RICHOUT	RICHTOHX	STRIPFEE	TOWASH	VAP1	VAP2	VAP3	VAP4	VAPOR	WASHWT	WATEROU
Temperature K	383.4	383.4	317.6	317.6	317.6	317.6		322.8	317.6	317.6	320.9	323.2	323.2	372.4	323.1	317.6	317.6	317.6	317.6	371	313.1	317.6
Pressure N/sqm	151987.5	170272.57	382659.03	961818.6	2417991	6.08E+06	1.53E+07	1.01E+05	1047917	1.01E+05	151987.5	101574.1	441777	166173	101574.1	382659	961818.6	2417991	6082555	151987.5	101101	103681
Vapor Frac	0	0	0	0	0	0		0	0	0	0	0	0	0.012	1	1	1	1	1	1	0	0
Mole Flow kmol/sec	44.733	44.733	0.044	0.013	0.005	0.001	0	1.015	44.731	42.986	0.949	44.798	44.798	45.07	8.188	0.844	0.831	0.826	0.825	1.838	1	0.684
Mass Flow kg/sec	1099.855	1099.855	0.799	0.227	0.088	0.026	0	18.289	1099.855	1068.47	17.153	1137.237	1137.237	1137.237	223.246	36.576	36.349	36.262	36.235	54.529	18.015	12.322
Volume Flow cum/sec	1.164	1.164	0.001	0	0	0	0	0.019	1.118	1.087	0.017	1.138	1.138	11.555	216.366	5.728	2.189	0.807	0.248	37.02	0.018	0.012
Enthalpy MMBtu/hr	-4.50E+04	-4.50E+04	-42.996	-12.2	-4.69	-1.402		-984.284	-4.59E+04	-4.42E+04	-921.804	-4.71E+04	-4.71E+04	-4.64E+04	-927.406	-1120.66	-1110.84	-1108.3	-1111.93	-1927.61	-972.04	-664.015
Mass Flow kg/sec																						
CO2	0.114	0.114	0.003	0.002	0.002	0.001	0	0	0	0	0.021	0.046	0.046	12.027	3.899	36.186	36.184	36.182	36.181	36.225	0	0.001
H2O	732.395	732.395	0.796	0.225	0.086	0.025	0	18.289	733.137	701.726	17.083	728.079	728.079	731.151	18.085	0.386	0.16	0.074	0.049	18.271	18.015	12.32
N2	0	0	0	0	0	0	0	0	0	0	0	0.004	0.004	0.004	181.221	0.004	0.004	0.004	0.004	0.004	0	0
O2	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0.001	20.04	0.001	0.001	0.001	0.001	0.001	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	4.314	4.314	0	0	0	0	0	0	1.366	1.312	0.021	21.764	21.766	12.385	0	0	0	0	0	0	0	0
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0.116	0.116	0	0	0	0	0	0	0.544	0.511	0	1.288	1.285	0.279	0	0	0	0	0	0	0	0
MEA	48.32	48.321	0	0	0	0	0	0	38.803	38.787	0	3.089	3.093	14.234	0	0	0	0	0	0.015	0	0
MEA+	45.729	45.727	0	0	0	0	0	0	52.686	52.542	0.015	59.523	59.519	54.51	0	0	0	0	0	0	0	0
MEACOO-	110.382	110.382	0	0	0	0	0	0	114.936	115.204	0	164.331	164.331	153.743	0	0	0	0	0	0	0	0
MDEA	96.792	96.79	0	0	0	0	0	0	112.967	112.781	0	44.262	44.257	61.77	0	0	0	0	0	0.01	0	0
AMP	18.288	18.288	0	0	0	0	0	0	15.312	15.189	0	2.211	2.213	7.683	0	0	0	0	0	0.003	0	0
AMP+	13.479	13.48	0	0	0	0	0	0	16.49	16.613	0.003	29.739	29.736	24.204	0	0	0	0	0	0	0	0
MDEA+	29.927	29.929	0	0	0	0	0	0	13.615	13.803	0.01	82.901	82.906	65.245	0	0	0	0	0	0	0	0
Mole Flow kmol/sec																						
CO2	0.003	0.003	0	0	0	0	0	0	0	0	0	0.001	0.001	0.273	0.089	0.822	0.822	0.822	0.822	0.823	0	0
H2O	40.654	40.654	0.044	0.013	0.005	0.001	0	1.015	40.695	38.952	0.948	40.415	40.415	40.585	1.004	0.021	0.009	0.004	0.003	1.014	1	0.684
N2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.469	0	0	0	0	0	0	0
O2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.626	0	0	0	0	0	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0.071	0.071	0	0	0	0	0	0	0.022	0.022	0	0.357	0.357	0.203	0	0	0	0	0	0	0	0
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0.002	0.002	0	0	0	0	0	0	0.009	0.009	0	0.021	0.021	0.005	0	0	0	0	0	0	0	0
MEA	0.791	0.791	0	0	0	0	0	0	0.635	0.635	0	0.051	0.051	0.233	0	0	0	0	0	0	0	0
MEA+	0.736	0.736	0	0	0	0	0	0	0.849	0.846	0	0.959	0.959	0.878	0	0	0	0	0	0	0	0
MEACOO-	1.06	1.06	0	0	0	0	0	0	1.104	1.107	0	1.579	1.579	1.477	0	0	0	0	0	0	0	0
MDEA	0.812	0.812	0	0	0	0	0	0	0.948	0.946	0	0.371	0.371	0.518	0	0	0	0	0	0	0	0
AMP	0.205	0.205	0	0	0	0	0	0	0.172	0.17	0	0.025	0.025	0.086	0	0	0	0	0	0	0	0
AMP+	0.15	0.15	0	0	0	0	0	0	0.183	0.184	0	0.33	0.33	0.269	0	0	0	0	0	0	0	0
MDEA+	0.249	0.249	0	0	0	0	0	0	0.113	0.115	0	0.69	0.69	0.543	0	0	0	0	0	0	0	0

Table 2. Partial Stream Table – 35% Amine Mix

	AMINEFD	CLEANER	CO2LIQ	COMBFD	COMP1ST	COMP2	COMP3	COMP4	COMP5	COMPFLU	FEEDGAS	FLUEGAS	GASFSTR	HOTCO2	LEANFRHX
Temperature K	317.6	323.8	317.6	317.6	396.8	392.9	394.3	398.1	401.3	328.2	317.6	327.6	320.9	317.6	327.8
Pressure N/sqm	101281	101352.93	1.53E+07	101574.09	382659.03	961818.6	2417991	6081865	1.53E+07	103681	103681	101101	151988	1.53E+07	1.70E+05
Vapor Frac	0	1	1	0	1	1	1	1	1	0.997	1	0.996	1	1	0
Mole Flow kmol/sec	1	8.23	0.823	35.62	0.886	0.842	0.829	0.825	0.823	9.489	8.805	9.489	0.886	0.823	36.309
Mass Flow kg/sec	18.015	224.016	36.155	934.3	37.292	36.495	36.269	36.181	36.155	268.03	255.708	268.03	37.292	36.155	946.716
Volume Flow cum/sec	0.018	218.396	0.054	0.951	7.571	2.798	1.065	0.391	0.128	248.724	223.987	254.282	15.452	0.054	0.968
Enthalpy MMBtu/hr	-970.899	-961.595	-1126.25	-3.70E+04	-1145.123	-1109.97	-1100.51	-1098.58	-1103.74	-2421.594	-1865.074	-2423.81	-1154.01	-1126.24	-3.75E+04
Mass Flow kg/sec															
CO2	0	3.924	36.102	0	36.11	36.107	36.105	36.103	36.102	40.038	40.037	40.038	36.11	36.102	0.001
H2O	18.015	18.829	0.049	569.167	1.179	0.385	0.16	0.074	0.049	26.725	14.404	26.725	1.179	0.049	581.52
N2	0	181.222	0.003	0	0.003	0.003	0.003	0.003	0.003	181.226	181.226	181.226	0.003	0.003	0
O2	0	20.041	0.001	0	0.001	0.001	0.001	0.001	0.001	20.041	20.041	20.041	0.001	0.001	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0	0	0	0.981	0	0	0	0	0	0	0	0	0	0	1.25
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0	0	0	0.357	0	0	0	0	0	0	0	0	0	0	0.293
MEA	0	0	0	42.094	0	0	0	0	0	0	0	0	0	0	43.402
MEA+	0	0	0	50.75	0	0	0	0	0	0	0	0	0	0	49.624
MEACOO-	0	0	0	112.572	0	0	0	0	0	0	0	0	0	0	112.229
MDEA	0	0	0	113.236	0	0	0	0	0	0	0	0	0	0	110.684
AMP	0	0	0	15.474	0	0	0	0	0	0	0	0	0	0	15.856
AMP+	0	0	0	16.326	0	0	0	0	0	0	0	0	0	0	15.939
MDEA+	0	0	0	13.344	0	0	0	0	0	0	0	0	0	0	15.917
Mole Flow kmol/sec															
CO2	0	0.089	0.82	0	0.82	0.82	0.82	0.82	0.82	0.91	0.91	0.91	0.82	0.82	0
H2O	1	1.045	0.003	31.594	0.065	0.021	0.009	0.004	0.003	1.483	0.8	1.483	0.065	0.003	32.279
N2	0	6.469	0	0	0	0	0	0	0	6.469	6.469	6.469	0	0	0
O2	0	0.626	0	0	0	0	0	0	0	0.626	0.626	0.626	0	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0	0	0	0.016	0	0	0	0	0	0	0	0	0	0	0.02
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0	0	0	0.006	0	0	0	0	0	0	0	0	0	0	0.005
MEA	0	0	0	0.689	0	0	0	0	0	0	0	0	0	0	0.711
MEA+	0.00%	0	0	0.817	0	0	0	0	0.00%	0	0	0	0	0	0.799
MEACOO-	0	0	0	1.082	0	0	0	0	0	0	0	0	0	0	1.078
MDEA	0	0	0	0.95	0	0	0	0	0	0	0	0	0	0	0.929
AMP	0.00	0	0	0.174	0	0	0	0	0	0	0	0	0	0	0.178
AMP+	0.00	0	0	0.181	0	0	0	0	0	0	0	0	0	0	0.177
MDEA+	0.00	0	0	0.111	0	0	0	0	0	0	0	0	0	0	0.132

Table 2. Remainder of Stream Table-35% Amine Mix

	LEANOUT	LEANTOHX	LIQ1	LIQ2	LIQ3	LIQ4	LIQ5	OUTWASH	REC	REC2	REFLUX	RICHOUT	RICHTOHX	STRIPFEE	TOWASH	VAP1	VAP2	VAP3	VAP4	VAPOR	WASHWT	WATEROU
Temperature K	384.1	384.1	317.6	317.6	317.6	317.6		323.8	317.6	317.6	320.9	323.3	323.4	372.6	324.1	317.6	317.6	317.6	317.6	371.2	313.1	317.6
Pressure N/sqm	151987.5	170272.57	382659.03	961818.6	2417991	6.08E+06	1.53E+07	1.01E+05	1047917	1.01E+05	151987.5	101574.1	441777	166173	101574.1	382659	961818.6	2417991	6082555	151987.5	101101	103681
Vapor Frac	0	0	0	0	0	0		0	0	0	0	0	0	0.014	1	1	1	1	1	1	0	0
Mole Flow kmol/sec	36.311	36.311	0.044	0.013	0.005	0.001	0	1.017	36.309	34.62	0.889	36.375	36.375	36.632	8.247	0.842	0.829	0.825	0.823	1.776	1	0.684
Mass Flow kg/sec	946.716	946.716	0.797	0.227	0.088	0.026	0	18.319	946.716	916.285	16.082	984.007	984.007	984.007	224.32	36.495	36.269	36.181	36.155	53.374	18.015	12.322
Volume Flow cum/sec	1.004	1.004	0.001	0	0	0	0	0.019	0.963	0.933	0.016	0.984	0.984	10.558	218.585	5.715	2.184	0.805	0.247	35.796	0.018	0.012
Enthalpy MMBtu/hr	-3.69E+04	-3.69E+04	-42.879	-12.173	-4.679	-1.399		-985.623	-3.76E+04	-3.60E+04	-863.691	-3.89E+04	-3.89E+04	-3.83E+04	-975.179	-1118.22	-1108.42	-1105.89	-1109.51	-1876.05	-972.04	-664.015
Mass Flow kg/sec																						
CO2	0.103	0.103	0.003	0.002	0.002	0.001	0	0	0	0	0.02	0.035	0.035	11.355	3.924	36.107	36.105	36.103	36.102	36.151	0	0.001
H2O	581.022	581.022	0.794	0.225	0.086	0.025	0	18.319	581.57	551.167	15.996	577.876	577.876	580.422	19.132	0.385	0.16	0.074	0.049	17.183	18.015	12.32
N2	0	0	0	0	0	0	0	0	0	0	0	0.003	0.003	0.003	181.223	0.003	0.003	0.003	0.003	0.003	0	0
O2	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0.001	20.041	0.001	0.001	0.001	0.001	0.001	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	3.156	3.155	0	0	0	0	0	0	1.002	0.95	0.029	16.94	16.941	9.056	0	0	0	0	0	0	0	0
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0.078	0.078	0	0	0	0	0	0	0.369	0.338	0	0.925	0.922	0.198	0	0	0	0	0	0	0	0
MEA	51.176	51.175	0	0	0	0	0	0	42.033	42.179	0	3.115	3.119	14.578	0	0	0	0	0	0.02	0	0
MEA+	43.583	43.584	0	0	0	0	0	0	50.842	50.613	0.021	56.298	56.293	51.841	0	0	0	0	0	0	0	0
MEACOO-	109.109	109.109	0	0	0	0	0	0	112.521	112.656	0	169.691	169.692	157.628	0	0	0	0	0	0	0	0
MDEA	96.492	96.492	0	0	0	0	0	0	113.312	113.117	0	42.929	42.921	59.447	0	0	0	0	0	0.013	0	0
AMP	18.327	18.327	0	0	0	0	0	0	15.525	15.393	0	2.113	2.115	7.366	0	0	0	0	0	0.003	0	0
AMP+	13.441	13.44	0	0	0	0	0	0	16.274	16.407	0.003	29.838	29.835	24.525	0	0	0	0	0	0	0	0
MDEA+	30.23	30.229	0	0	0	0	0	0	13.268	13.464	0.013	84.245	84.253	67.588	0	0	0	0	0	0	0	0
Mole Flow kmol/sec																						
CO2	0.002	0.002	0	0	0	0	0	0	0	0	0	0.001	0.001	0.258	0.089	0.82	0.82	0.82	0.82	0.821	0	0
H2O	32.252	32.252	0.044	0.012	0.005	0.001	0	1.017	32.282	30.594	0.888	32.077	32.077	32.218	1.062	0.021	0.009	0.004	0.003	0.954	1	0.684
N2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.469	0	0	0	0	0	0	0
O2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.626	0	0	0	0	0	0	0
HCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H3O+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO3-	0.052	0.052	0	0	0	0	0	0	0.016	0.016	0	0.278	0.278	0.148	0	0	0	0	0	0	0	0
CL-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3--	0.001	0.001	0	0	0	0	0	0	0.006	0.006	0	0.015	0.015	0.003	0	0	0	0	0	0	0	0
MEA	0.838	0.838	0	0	0	0	0	0	0.688	0.691	0	0.051	0.051	0.239	0	0	0	0	0	0	0	0
MEA+	0.702	0.702	0	0	0	0	0	0	0.819	0.815	0	0.907	0.907	0.835	0	0	0	0	0	0	0	0
MEACOO-	1.048	1.048	0	0	0	0	0	0	1.081	1.082	0	1.63	1.63	1.514	0	0	0	0	0	0	0	0
MDEA	0.81	0.81	0	0	0	0	0	0	0.951	0.949	0	0.36	0.36	0.499	0	0	0	0	0	0	0	0
AMP	0.206	0.206	0	0	0	0	0	0	0.174	0.173	0	0.024	0.024	0.083	0	0	0	0	0	0	0	0
AMP+	0.149	0.149	0	0	0	0	0	0	0.181	0.182	0	0.331	0.331	0.272	0	0	0	0	0	0	0	0
MDEA+	0.252	0.252	0	0	0	0	0	0	0.11	0.112	0	0.701	0.701	0.562	0	0	0	0	0	0	0	0